THE CLASPING ORGANS OF EXTINCT AND RECENT AMPHIBIA.

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In the eastern part of Ohio, in the valley of Yellow Creek and near the town of that name though formerly known as Linton, there are some old deserted coal mines which are of interest to the paleontologist on account of the number of vertebrate remains which have been obtained from them. Dr. J. S. Newberry secured from the old Diamond mine near Linton a large amount of material, both of fishes and amphibians. There have been more than a score of fishes described from this collection and nearly two score amphibians.[1] The specimens occur on blocks of coal shale which are obtained from a thin stratum of cannel, a few inches in thickness, underlying over a limited area, a thick bed of cubical coal which is known as the "Ohio No. 6." This is probably the equivalent of the Middle Kitanning Coal of Pennsylvania[2] and is hence in the Allegheny series of the Pennsylvanian.

The remains are always crushed flat but in the majority of cases the minutest details are preserved, although the original form of the bony structure has disappeared and is replaced by carbonaceous matter. In some cases the animal is represented by a mere mold of the carbonaceous shale which formed around it. Of the amphibians known from the Diamond mine there are forty-six species, which are in large part represented by fragments but sometimes by incomplete skulls and in a few cases by nearly complete skeletons of the entire animal. Among the objects collected at this locality were some short comb-like bodies found associated with the amphibian remains and it is to these objects that the reader's attention is here invited.

These elements consist of slender rods which terminate in expanded comb-like ends, the handle being usually from one to two times as long as the comb. The comb is formed of a thick

[1] Newberry, 1889, Monograph, U. S. G. S., Vol. XVI., p. 211.
[2] Orton, 1893, Geol. Surv. Ohio, Vol. VII., p. 279.

body with a series of pectinations which are continuous with ridges, separated by grooves occurring on the body of the expansion. The pectinations are not always regular and do not always project from the body. In a few cases they are lacking entirely. The handle may be round, triangular or flattened and is usually more or less curved toward the pectinated edge. In some cases the entire clasping organ may be S-shaped, one of the curves occurring in the body of the comb.

The comb-like bodies were first described and figured by Fritsch in 1879 from the Permian rocks of Bohemia. Previous writers had regarded these objects as the jaw bones of fishes or lizards but further research brought out the fact, first indicated by Fritsch, that they could not be jaws since they were entirely covered by an enamel-like substance.[1] They were found associated with the remains of *Ophiderpeton pectinatum* Fritsch and the species is defined as follows: "Stäbchen des Bauchpanzers dreimal so lang als die Wirbel, rauh! Kammplatten liegen zu wenigstens 3 Paar in der Aftergegend (?)." Fritsch regarded the "Kammplatten" as occurring in the cloacal region on account of the position in which they were found on a block of shale with portions of the pelvis of the species. "Später erhielt ich ein Stück Bauchpanzer eines Ophiderpeton, neben welchen zwei dieser rätselhaften Gebilde lagen und diess brachte mich auf die Idee, dass die Kammplatten modificirte Stäbchen des Bauchpanzers sind, welche wahescheinlich in der Kloakengegend als Hilfsorgane bei der Paarung dienten."

In 1901, when the last volume of the "Fauna der Gaskohle" was issued, Fritsch figured and described another species of *Ophiderpeton*, *O. persuadens* Fr. with the "Kammplatten" in place near the cloacal region of the specimen which was composed of over one hundred consecutive vertebræ and had a length of 15 cm. Only a portion of the tail was lost. Fritsch says in regard to this species: "Das interessanteste bei diesem Exemplar ist, dass in der Nähe des Afters zwei Rudimente von Kammplatten liegen, . . . welche meine Vermuthung bestätigen dass diese Organe in der Cloakengegend gelegen, ein Hilfsapparat bei der Paarung waren."[2]

[1] Fritsch, 1883, "Fauna der Gaskohle," Vol. I., p. 122.

[2] Fritsch, 1901, "Fauna der Gaskohle," Supplement, Vol. IV., p. 89.

In 1881 Stock reviewed the work on the clasping organs or "Kammplatten" and gave figures of several forms which were found in the coal of Northumberland county of England[1] (Fig. 1). He referred to several species of fish which had been based on objects identical with the "Kammplatten." In the same year, 1881, Traquair had established a new genus of fish, *Euctenius*, on a clasping organ of an amphibian, obtained from the "Black-band Ironstone" near Edinburgh.[2] In a communication to Stock, Traquair admitted that he had come to this conclusion in regard to the *Euctenius*. Barkas, in 1869, had described two species of *Ctenoptychius* based on remains which are identical with the clasping organs in question[3] (Fig. 2). The elements discovered and figured by Stock from the Northumberland Coal-measures consisted of objects which he compares in form to a

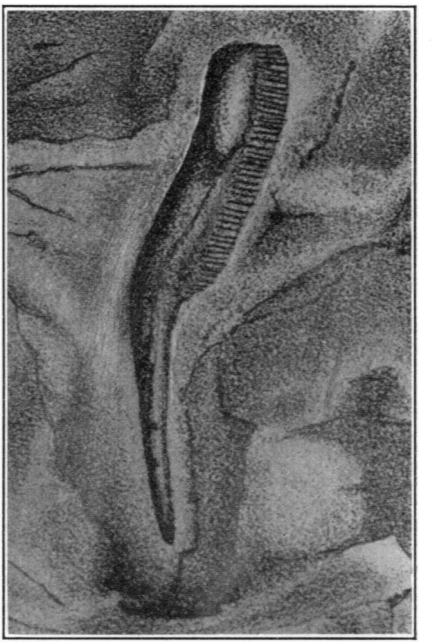

FIG. 1. "Kammplatten" from the Northumberland coal of England. After Stock.

FIG. 2. "*Ctenoptychius*" tooth — clasping organ. After Barkas.

tadpole. They are elongate rods with an expanded end, a rather long narrow handle and a short broad body on one edge of which

[1] Stock, 1881, *Ann. and Mag. Nat. Hist.*, 5th Ser., Vol. VIII., p. 90 with Plate VI.

[2] Traquair, 1881, *Geol. Mag.*, Decade II., Vol. 8, p. 36.

[3] Barkas, 1869, *Geol. Mag.*, Vol. VI., p. 43.

there are set fine serrated tooth-like projections varying in number from fifteen to sixty.

Cope announced the discovery of similar bodies in the Linton, Ohio, beds in 1885[1] and compared them to the elements described and figured by Fritsch as "Kammplatten." He says in regard to them: "They consist of a curved rod terminating in a secund expansion, whose projecting edge is divided into fine teeth like a comb" and they "differ from those described by Fritsch, in the greater curvature of the shaft in the direction to which the teeth present. Its axis is nearly at right angles to that of the body of the bone." In this connection he refers to similar bodies found by him in the Laramie deposits of Montana to which he had given the name *Ceratodus hieroglyphus* which he later changed to *Arotus hieroglyphus*. Hay in his "Catalogue of Fossil Vertebrata of North America" retains the name under *Ceratodus*.

Cope's description of the element in question is as follows: "The dentigerous plate is thin and dense, and has the appearance of a short toothed comb with a handle. The tooth-like points

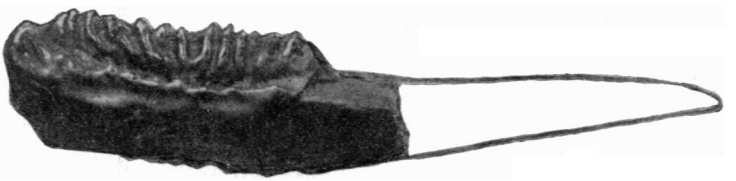

FIG. 3. Cope's *Ceratodus hieroglyphus* from the Laramie of Montana. × 4.

are the extremities of low ridges, which are arranged nearly at right angles to a wide longitudinal elevated half of the osseous base. They are separated by shallow grooves from each other and are not continuous with the basis just mentioned, which rises abruptly above them. They are smooth. The 'handle' above alluded to is triangular in section having two bevels on the side supporting the tooth ridges. The lower face of the bone is smooth.

MEASUREMENTS.	M.
Total length	.013
Length of dentigerous portion	.010
Total width	.0045
Width of dentigerous portion	.0020

"There are thirteen teeth in the length"[2] (Fig. 3).

[1] Cope, 1885, *Pal. Bull.*, No. 40, p. 405.

[2] Cope, 1876, *Proc. Acad. Nat. Sci. Phila.*, p. 260.

Through the kindness of Dr. L. Hussakof of the American Museum, I have had the opportunity to examine the object described by Cope and am able to verify his description. The fragment, which lacks the greater part of the handle, is of a reddish brown color and is covered with a shining enamel very similar to that described by Fritsch for the clasping organs of *Ophiderpeton*. The object has very little resemblance to a *Ceratodus* tooth, as may be seen by referring to the figure herewith given (Fig. 3).

In the Laramie deposits remains of five species of Amphibia have been discovered. The forms, the fragments of which are rather abundant in the deposits, are based on small portions of the skeleton which are typically amphibian in structure. The forms described from the Laramie Cretaceous of North America are: *Scapherpeton tectum* Cope, based on a single vertebra with a fragment of another bone; *S. laticolle* Cope, based on several vertebræ and a limb bone; *S. excisum* Cope, based on several vertebræ; *S. favosum* Cope, based on a single vertebra, and *Hemitrypus jordanianus* Cope, based on a single vertebra.[1] Lambe has figured vertebræ of *Scapherpeton tectum* Cope, and provisionally referred fragments of a jaw to this species from the Judith River beds of Canada.[2]

Cope suggests[3] that the comb-like bodies described above may have been the clasping organs of the *Scapherpeton* forms of the Laramie. The element described as *Ceratodus hieroglyphus* Cope, certainly agrees in every detail with the amphibian elements figured and described by Fritsch and Stock and there can be no doubt that it is not a fish tooth but is probably the clasping organ of some one of the Laramie Amphibia. If it is the clasping organ of some one of the Laramie amphibians certain interesting deductions would necessarily follow. Among the earlier forms the clasping organs are only known among some of the Carboniferous Microsauria and Aistopoda. If these organs are present in the Laramie forms and also in the Carboniferous forms there must be some genetic relationship between them. *Hylæobatrachus* from the Wealden of Europe does not

[1] Cope, 1876, Proc. Acad. Nat. Sci. Phila., pp. 353–359.

[2] Lambe, 1902, *Contrib. Canad. Paleon.*, Vol. III., Pt. II., p. 31.

[3] Cope, 1885, *Pal. Bull.*, No. 40, p. 408.

exhibit, so far as I am aware, any evidences of the clasping organs and this is the only form which is intermediate in age between the Carboniferous forms and the Laramie ones. The Labyrinthodontia which existed in the Permian and Trias are highly specialized and so cannot be taken into account in this regard. Newberry,[1] however, was strongly inclined to the idea that the "Kammplatten" were in reality fish teeth as Barkas and Traquair had thought. He says it will take strong evidence to convince him of the fact that they are amphibian. He mentions the discovery of several of the "Kammplatten" in the Linton beds and says they differ but little from those described by Fritsch.

Fortunately the exact location of those objects in the anatomy of the extinct amphibians is not a matter of conjecture, but of actual knowledge, since Fritsch has discovered them in place on the specimen of *Ophiderpeton persuadens* Fr. above referred to. That they are but modified elements of the ventral armature is also beyond a doubt since Fritsch found intermediate forms of the ventral chevron rods and figured several of them. A copy of one of these rods is given in Fig. 4. The abdominal arma-

FIG. 4. A slender, toothless clasping organ from the Permian of Bohemia. After Fritsch.

ture is almost universal among the Carboniferous forms of the Amphibia, being unknown in a few forms such as *Pelion lyelli* Wyman and *Molgophis macrurus* Cope, so that we may expect to learn of forms which had the clasping rods developed and of which there is now no knowledge. What purpose the abdominal chevron rods served is not at present apparent but that the posterior rods near the cloacal region became specialized into clasping organs for the retention of the female during the breeding season seems almost beyond dispute.

Since the clasping organs are thus shown to be but specialized

[1] Newberry, 1889, Monograph, U. S. G. S., Vol. XVI., p. 228.

parts of the abdominal armature it is to be expected that the forms of the Amphibia which lived during Laramie times would have the armature well developed as they almost certainly had the clasping organs. When the Laramie Amphibia are better known they will, without doubt, be found to have at least some representation of an abdominal armature.

How these clasping organs served the purpose for which they seem to be developed is, in large part, a matter of conjecture since we do not know and in all probability never can know the method of copulation in the extinct forms. It is a matter which is well known that the male of the common newt retains the female by means of roughnesses developed on the inner side of the hind limbs and why may not the clasping organs, above described, have served the extinct forms in a similar manner? Of course it is readily seen that they would be of more service to the limbless forms like *Ophiderpeton* than they would to forms like *Scapherpeton* which, in all probability, had well developed limbs. It is possible that the clasping organs in *Scapherpeton*, if they belong to this form, were vestigial and were not functional or they may have belonged to limbless forms of which there is no knowledge unless *Hemitrypus* is a limbless amphibian.

So far as I am aware, the clasping organs are found in association with limbless forms only. Such was the case in all of those described by Fritsch. The form of limbless amphibian described by Huxley[1] from the Coal-measures of Ireland seems not to have had the clasping organs preserved or at least they have not been detected. The "Kammplatten" discovered by Stock, Barkas and Traquair in the rocks of England were not associated with other remains so we do not know to what type of amphibian they belonged, although a species of *Ophiderpeton*, *O. nanum* Hancock and Atthey, has been described from this region. In the Linton, Ohio, deposits there occur a number of forms which are limbless. The species of *Ptyonius*, *Molgophis*, *Hyphasma*, *Phlegethontia* and possibly a species of *Osetocephalus* also was limbless, although there would seem to be indications of limbs in the other species. In any case the first four probably do not possess limbs and in *Molgophis*, apparently, the abdominal rods

[1] Huxley, 1867, *Trans. Roy. Irish Acad.*, Vol. XXIV., p. 353.

were not developed so that clasping organs may safely be ascribed to species of the other three genera. There is no reason why the limbed forms might not also have possessed the clasping organs.

Among the recent Amphibia, so far as I am aware, there are no bony or cartilaginous elements in the abdominal wall. Both the chevron armature of the extinct forms and the well developed " Kammplatten " are absent among the modern Amphibia. The recent forms do, however, have well developed clasping organs, at least in some cases. It will be of interest, in this connection, to examine the condition of the clasping organs in the recent forms as a comparison to those found in the extinct species.

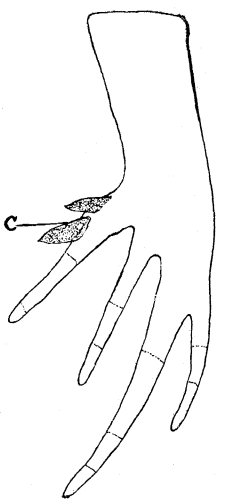

FIG. 5. The right hand of *Leptodactylus*. From a specimen in the Field Museum. Enlarged.

Among the Salientia the clasping organs are usually developed on the fore limbs and consist for the large part of wart-like or spine-like excresences on the skin. These asperities are developed on the inner side of the fore legs and on the breast of the males. " Nuptial excrescences on the inner metacarpal tubercle and on the inner fingers of the male are common ; they reach their greatest development in the Himalayan *Rana liebigi*, the male of which is ' remarkable for the extreme thickness of its arms, the inner sides of which are studded with small conical black spines, each supported on a rounded base produced by a swelling of the skin. A large patch of similar spines exists on each side of the breast.' " [1]

In the genus *Leptodactylus*, from Central and South America, a specimen of which I have studied in the Field Museum, the first digit is somewhat swollen to support two black, horny spines (Fig. 5), which project on the inner side of the finger. There are many variations of these two extreme cases cited above but in all they are on the same general plan. In most cases the clasping organs are only developed during the breeding season.

[1] Boulenger, " Cat. Batrach. Salientia," p. 22. Gadow, 1901, " Amphibia and Reptiles," p. 250.

Among the Caudata the clasping organs are almost always developed on the hind limbs. They were first observed in the common newt, according to Jordan,[1] by Braun in 1878 on the European species *Diemyctylus alpestris*. During the breeding season there are developed "all the way up and down the inside of the hind legs as well as on the adjoining parts of the body, round, black, wart-like elevations. These warts are hard and rough and undoubtedly aid the male in clasping the female more firmly." [2]

There are numerous other instances cited in the literature in which similar structures have been observed in the males but they are all in general plan similar to those of *Diemyctylus* where they are only developed during the breeding season and subsequently turn yellow, become soft and then disappear.

The phylogeny of the modern Amphibia is one of the most obscure of any of the groups of vertebrates. The modern forms are for the most part degenerate in structure and in no way compare to the robust forms of the Carboniferous, some of which, at least, must have been their ancestors. The Amphibia on the whole have played but a small part in the history of animal life on the earth. They have never become the dominant type in any age as did the fishes, reptiles and mammals. They have always, so to speak, filled in the corners, left by their more aggressive contemporaries. Their chief interest lies in that they were the ancestors of the higher forms of life.

The modern Amphibia are for the most part shy, harmless creatures although there is an interesting exception to this in the case of the horned frog, *Ceratophrys*, one species of which, according to Lydekker, is "exceeding bold and ferocious, flying fiercely at anyone who attacks them, and maintaining their hold with the tenacity of a bull-dog, at the same time uttering a kind of barking cry." [3] We have abundant evidence that in the old pond or lake which was once located, during the Carboniferous period, near the place where was recently situated the town of Linton, Ohio, that the Amphibia, like the recent *Ceratophrys*, were of a

[1] Jordan, 1891, *Journ. Morphol.*, Vol. V., No. 2, p. 263.
[2] Jordan, *loc. cit.*, p. 264.
[3] Lydekker, "New Natural History," Vol. V., p. 275.

ferocious disposition. They were well fitted for such a life armed as they were, in some cases, with long, strong teeth and hard dermal plates and scales. There is an abundance of evidence to their carnivorous habits in the coprolites preserved with their remains. As some of the forms of the Carboniferous may have reached a length of some ten to twelve feet they would be ferocious creatures to attack in comparison to the modern degenerate forms. The suggestion as to the evolution and ancestry of at least one group of the modern Amphibia will be given elsewhere but the rocks have not yielded, as yet, a great amount of information which might serve to connect the old and recent forms.

The earliest geological evidence of Amphibia are the foot-tracks described by Lea in 1849, and subsequently made more fully known by Marsh, from the Catskill Formation, Upper Devonian, of Pennsylvania. The next evidence is that of abundant remains of amphibians from the Allegheny series of the Pennsylvanian in North America and in probably equivalent strata in Europe. Abundant remains are known, also, from the Permian of North America and Europe. Fritsch and Credner, especially, have described abundant faunæ from the Permian rocks of Bohemia and Saxony and Cope has done the same for the Permian beds in North America. In the Triassic the majority of the Amphibia are the highly specialized stereospondylus labyrinthodonts, although a few smaller and more primitive forms are known. The next evidence of Amphibia is the discovery by Dollo of a complete skeleton of a perennibranchiate salamandrine form from the Wealden of Bernissart.[1] From *Hylæobatrachus* in the Wealden to the forms described by Cope from the Laramie Cretaceous of Montana our knowledge of the Amphibia is a blank. The forms must have existed somewhere but their remains have not yet been discovered. Marsh, it is true, gave a name to some fragments from the Lower Cretaceous of Wyoming but these he never figured and never described and so far as our knowledge of the form goes the name *Eobatrachus agilis* Marsh may be considered as a mere *nomen nudum*. In the Eocene rocks, remains of Amphibia are fairly abundant but they represent types which compare with the modern forms in structure and in no way

[1] Dollo, 1884, *Bull. Mus. Roy. Hist. Nat. de Belg.*, III., p. 85.

resemble the ancient species. In the Miocene rocks of Switzerland occurs the famous *Andrias scheuchzeri* Tschudi, which is related to the Japanese salamander of to-day. In the Pleistocene are found remains which belong to species of modern genera.

That the transition between the ancient and the recent forms took place between the close of the Permian and the close of the Cretaceous is evident. This transition consisted in the loss of the ventral armature, the loss of sclerotic plates, the loss of dermal plates, the loss of the bony clasping organs, the loss of the supra-occipital and epiotic elements from the skull and the loss of strong teeth. The modern Amphibia are degenerate in structure. The bridge which may help to close the gap between the Paleozoic and the Mesozoic forms is the fact that similar bony clasping organs are, apparently, developed in the forms of the two periods. If this be true it will be of service in closing one of the widest gaps in vertebrate phylogeny.